

I CLAIM:

1. A method of determining an amount of cathodic protection current to be applied to an underground metallic structure in contact with an underground earth formation, the structure having an extended underground length extending through a corrosive zone of the formation, with one end of the length being substantially near the earth's surface and another end of the length being below the corrosive zone, said method comprising the steps of:

mechanically connecting a first axial current meter (ACM) to the structure at a first underground depth substantially just above the corrosive zone for measuring a

- 10 first axial current flowing through the structure at the first depth;

mechanically connecting a second axial current meter to the structure at a second underground depth substantially just below the corrosive zone for measuring a second axial current flowing through the structure at the second depth;

connecting a master axial current meter (MACM) to the structure substantially near the earth's surface;

operating the MACM over a selected limited time period to periodically obtain a series of first measurements of the first axial current from the first ACM and a series of second measurements of the second axial current from the second ACM, each second measurement being obtained at substantially the same time as a

- 20 corresponding first measurement; and

determining from the first and second measurements, an amount of cathodic protection current to be applied to the structure to avoid corrosion of the structure in the corrosive zone.

2. The method of claim 1, wherein the structure is a well casing.

3. The method of claim 2, wherein said step of mechanically connecting the first ACM to the well casing includes the step of mechanically connecting the first ACM to a first sub and the step of mounting the first sub on the well casing at the first depth.

4. The method of claim 2, wherein said step of mechanically connecting the second ACM to the well casing includes the step of mechanically connecting the second ACM to a second sub and the step of mounting the second sub on the well casing at the second depth.

5. The method of claim 2, wherein said step of operating the MACM occurs over approximately six months.

6. The method of claim 2, wherein each of the first and second ACMs is normally in an inactive state, wherein said step of operating the MACM includes the step of periodically remotely activating the first and second ACMs to measure the

respective axial currents and to send the measurements to the MACM, and wherein each of the first and second ACMs returns to the inactive state after sending the respective measurement to the MACM.

7. The method of claim 6, wherein the well casing has a coating, and wherein said step of remotely activating includes the step of sending a respective activating signal through the coating to each of the first and second ACMs.

8. The method of claim 6, wherein the well casing is uncoated and has a cable extending from the MACM to each of the first and second ACMs, and wherein said step of remotely activating includes the step of sending a respective activating signal through the cable to each of the first and second ACMs.

9. The method of claim 1, wherein each of the first and second ACMs is normally in an inactive state, wherein said step of operating the MACM includes the step of periodically remotely activating the first and second ACMs to measure the respective axial currents and to send the measurements to the MACM, and wherein each of the first and second ACMs returns to the inactive state after sending the respective measurement to the MACM.

10. The method of claim 9, wherein the structure has a coating, and wherein said step of remotely activating includes the step of sending a respective activating signal through the coating to each of the first and second ACMs.

11. The method of claim 9; wherein the structure is uncoated and has a cable extending from the MACM to each of the first and second ACMs, and wherein said step of remotely activating includes the step of sending a respective activating signal through the cable to each of the first and second ACMs.

12. The method of claim 1, further comprising the steps of:
connecting a source of cathodic protection current between the structure and an anode bed; and
applying the determined amount of cathodic protection current from the source to the structure.

13. An apparatus for determining an amount of cathodic protection current to be applied to an underground metallic structure in contact with an underground earth formation, the structure having an extended underground length extending through a corrosive zone of the formation, with one end of the length being substantially near the earth's surface and another end of the length being below the corrosive zone, said apparatus comprising:

a first axial current meter (ACM) mechanically connected to the structure at a first underground depth substantially just above the corrosive zone for measuring a first axial current flowing through the structure at the first depth;

5 a second axial current meter mechanically connected to the structure at a second underground depth substantially just below the corrosive zone for measuring a second axial current flowing through the structure at the second depth;

 a master axial current meter (MACM) connected to the structure substantially near the earth's surface; and

10 a connecting structure for carrying signals between said MACM and each of
 said first and second ACMs,

 wherein said MACM includes a control for operating over a selected limited time period to periodically obtain a series of first measurements of said first axial current from said first ACM and a series of second measurements of said second axial current from said second ACM, each second measurement being obtained at
15 substantially the same time as a corresponding first measurement, and

 wherein said MACM provides information based on said first and second measurements for determining an amount of cathodic protection current to be applied to the structure to avoid corrosion of the structure in the corrosive zone.

14. The apparatus of claim 13, wherein the structure is a well casing.

15. The apparatus of claim 14, wherein said first ACM is mechanically connected to a first sub and said first sub is mounted on the well casing at the first depth.

16. The apparatus of claim 14, wherein said second ACM is mechanically connected to a second sub and said second sub is mounted on the well casing at the second depth.

17. The apparatus of claim 14, wherein said MACM is operated over approximately six months.

18. The apparatus of claim 14, wherein each of said first and second ACMs is normally in an inactive state, wherein said MACM periodically remotely activates said first and second ACMs to measure the respective axial currents and to send the measurements to said MACM, and wherein each of said first and second ACMs returns to the inactive state after sending the respective measurement to said MACM.

19. The apparatus of claim 18, wherein the well casing has a coating, and wherein said MACM sends a respective activating signal through the coating to each of said first and second ACMs.

20. The apparatus of claim 18, wherein the well casing is uncoated and has a cable extending from said MACM to each of said first and second ACMs, and wherein said MACM sends a respective activating signal through the cable to each of said first and second ACMs.

21. The apparatus of claim 13, wherein each of said first and second ACMs is normally in an inactive state, wherein said MACM periodically remotely activates said first and second ACMs to measure the respective axial currents and to send the measurements to said MACM, and wherein each of said first and second ACMs returns to the inactive state after sending the respective measurement to said MACM.

22. The apparatus of claim 21, wherein the structure has a coating, and wherein said MACM sends a respective activating signal through the coating to each of said first and second ACMs.

23. The apparatus of claim 21, wherein the structure has a cable extending from said MACM to each of said first and second ACMs, and wherein said MACM sends a respective activating signal through the cable to each of said first and second ACMs.

24. The apparatus of claim 13, further comprising a source of cathodic protection current connected between the structure and an anode bed, said source applying the determined amount of cathodic protection current to the structure.